RUI: Correlated Electrons in Multilayer Semiconductors

Charles Hanna, Boise State University, DMR Award #9972332

Multilayer semiconductor devices with nanoscale layer separations and low electron densities are important technologically and scientifically. The technological interest stems from the need to understand the electronic properties of semiconductor devices with ultrasmall feature sizes and very low electron densities, a regime that is rapidly being approached in the semiconductor industry. The scientific importance of these devices is that they are ideal arenas to investigate the fundamental quantum many-body physics of confined, interacting electrons.

The PI's research program emphasizes working with mentored undergraduates to calculate the electronic properties of bilayer, multilayer, and other nanoscale systems. The PI has worked with undergraduate students to model the following systems:

Bilayer systems in zero magnetic field, with ultrasmall layer separations and ultralow electron or hole densities.

Bilayer and superlattice quantum Hall systems, where many-body effects are dominant.

Quantum-dot cellular automata, a paradigm for low-power, few-electron nanoscale computing.

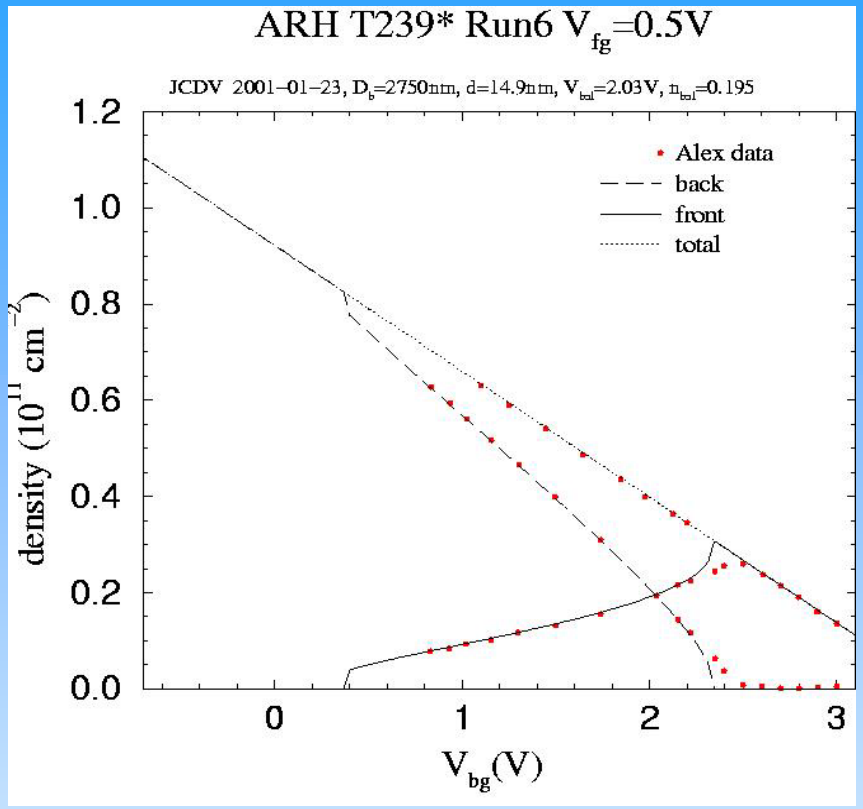

Figure 1. The PI's undergraduate students developed and used programs to fit experimental Shubnikov-de Haas data of layer densities versus voltage for low-density bilayer hole samples measured by Professor A.R. Hamilton. The model used is described in: C.B. Hanna, Dylan Haas, and J.C. Diaz-Velez, *Phys. Rev. B* **61**, 13882-13913 (2000).

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Educational:
The PI mentored 3 undergraduate students:
•Dylan Haas
•Juan Carlos Diaz-Velez
•James Rodriguez
These undergraduate students worked part time during the academic year and full time during the summer on these and related projects. They received training in computer programming, modern physics, physical modelling, mathematical analysis, and public speaking.

Collaborators:
The PI actively collaborated with 3 faculty,
•A.R. Hamilton, University of New South Wales (experimental condensed-matter physics)
•J.C. Lusth, Boise State University (computer science)
•A.H. MacDonald, University of Texas at Austin (theoretical condensed-matter physics)

Brief summary of outreach activities:
•The PI recruited and mentored the Physics Department's first two Hispanic physics majors.
•The PI and his students organized and presented a classroom recruiting session to encourage students from migrant farm worker families to pursue careers in science or engineering.

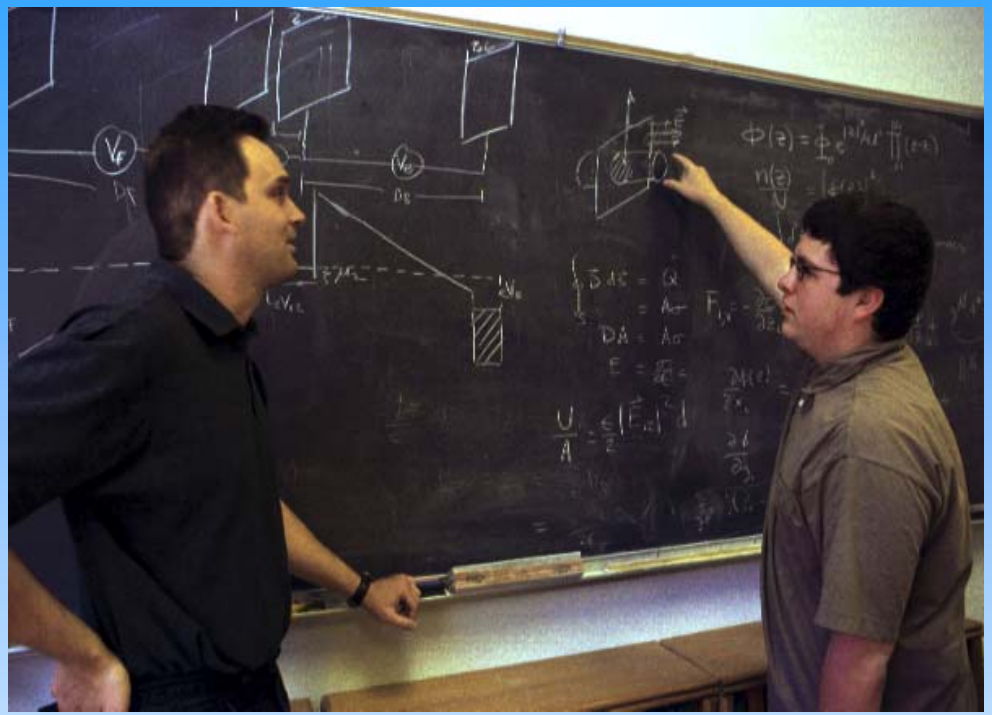

Figure 2. Juan Carlos Diaz-Velez (at left) and James Rodriguez discuss how to model double-layer electron systems. Both students have been supported by the NSF through DMR-9972332 as undergraduate research collaborators mentored by the PI.